Ohio Environmental Protection Agency

John R. Kasich, Governor
Mary Taylor, Lt. Governor
Craig W. Butler, Director

December 27, 2017

Mr. Billy R. Spencer
Mayor, Village of Piketon
411 West Street
Piketon, Ohio 45661

Re: US DOE PORTS
General Correspondence
Remedial Response
Pike County
I.D.#466000865

Dear Mayor,

I would like to thank you for attending the meeting hosted by Speaker Rosenberger and attended by staff from Senators Portman and Brown and Congressman Wenstrup's office on December 20, 2017. It was a good opportunity to again exchange information and understand your concerns about the Department of Energy and their continued efforts to decommission the nearby gaseous diffusion plant site and ready it for future development.

Ohio EPA has had extensive communications with you, your consultant, as well as other members of the community about the development of an on-site disposal cell to dispose of the large amounts of construction debris (some of which will be low level radioactive waste) generated from the decommissioning process. We have patiently and thoroughly explained in person and in writing how the process of approval and construction of this cell is largely, under federal law, determined by DOE, with significant oversight from Ohio EPA. And while your concerns and claims against DOE are varied, the most significant to me have been the concerns that the on-site location where the cell is being constructed is unsuitable because the underlying bedrock is not competent to withstand the weight of the cell. You have also raised concerns that the bedrock is fractured and will, if the cell ever does leak, will impact groundwater in the area.

At the December 20, 2017 meeting an Ohio EPA geologist tasked with reviewing the data from DOE gave a brief presentation to address the above concerns and inaccurate claims that this location is unsuitable. As we have several times previously, we presented in great detail evidence in the form of photographs of the rock cores, rock quality data, and pump tests results which directly counter the claims of the bedrock being "highly fractured" and unsuitable. We also presented regional groundwater flow maps which clearly counter incorrect assertions regarding regional ground water flow and claims that nearby community water wells are in jeopardy of contamination.

Beyond the most recent presentation, Ohio EPA geologists, engineers, and professional staff have and continue to provide competent oversight of the cell development and construction and believe the science supports the conclusions by DOE that this is a suitable location to develop the cell and that human health and the environment will be protected. Nonetheless, as I discussed at the meeting, we often seek outside review of our work when presented with very important, technical issues so as to provide the public with a high level of confidence the right decisions are made. In this case beyond our own review we have discussed the site and our conclusions with geologists at Ohio Department of Natural Resources, Geologic Survey. In short, they support our conclusions. Further, since you had specifically called for the federal U.S. EPA to be involved in reviewing this site, I personally asked the U.S. Environmental Protection Agency to review the DOE data and provide their unbiased technical conclusions relative to your concerns about the underlying bedrock.

We discussed U.S. EPA's findings at our recent meeting but I wanted to make sure you had copies of the U.S. EPA findings so you could personally review them. I have attached to my letter to you, a letter from U.S. EPA which includes reviews from two U.S. EPA subcontractors Akana and Booze Allen Hamilton. These unbiased and undisputedly qualified organizations clearly conclude that the underlying bedrock is strong enough to support the weight of the cell. Further, they conclude the underlying aquifer (Berea) is not connected hydraulically to, and thus protected by, the overlying geology. In short, U.S. EPA and their independent scientists clearly believe the investigations and conclusions by DOE and Ohio EPA are scientifically reasonable and accurate. I hope you review this information and conclude that our collective unbiased, comprehensive review is sufficient to allay your concerns and allow you to support work at the site.

Lastly, as we also discussed at our recent meeting, we have been working closely with DOE, Senator Portman, and others to provide clarity to the commitment from DOE to excavate the historical landfills within the Perimeter Road so this land can safely be developed in the future. It is our shared position that these landfills need to be excavated and placed in the on-site cell to support future development, as well as enhance protection to the environment and public health. You have seen my most recent letter dated December 6, 2017 to DOE stating that DOE need be more definitive in this commitment. And as you now know, Senator Portman has personally discussed this with DOE Secretary Perry. I am confident this issue will be resolved soon and your support is appreciated.

Thank you for your leadership in making sure the DOE on-site cell construction review has been completed by highly competent government and private scientists. Your efforts to have the best and most robust review of the science possible will certainly provide assurances to the public that the site can be safely cleaned up, the environment and public health protected, and that the site will be ready for a future mission to benefit Ohio.

Sincerely,

Craig W. Butler, Director
Ohio Environmental Protection Agency

Enclosure

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

DEC 1 8 2017

REPLY TO THE ATTENTION OF

Mr. Jim Sferra
Assistant Chief
Division of Environmental Response and Revitalization
Ohio Environmental Protection Agency
P.O. Box 1049
Columbus, Ohio 43216-1049

RE: Technical Review of Structural Stability and Hydrological Interconnectedness of Geological Units Associated with the Onsite Disposal Cell Portsmouth Gaseous Diffusion Plant, Piketon, Ohio

Dear Mr. Sferra:

On November 16, 2017, the Ohio Environmental Protection Agency (OEPA) asked the US Environmental Protection Agency for an expedited reasonableness review of geological competency for the proposed location of the Onsite Disposal Cell (OSDC) at the Department of Energy's (DOE) Portsmouth Gaseous Diffusion Plant in Piketon, Ohio (PORTS). Specifically, OEPA asked EPA to evaluate bedrock competency at the OSDC and the nature of fractures defined in boring logs and whether there is risk to the protection of groundwater under the OSDC.

EPA utilized internal expertise and assistance from government contractors Booze Allen Hamilton (BAH) and Akana to review the materials provided by OEPA in the short timeframe afforded. The attached evaluations are reviews of the OSDC's structural competency provided by Akana (Enclosure A) and EPA Office of Research and Development (Enclosure B), as well as independent reviews on the nature of discontinuity in boring logs and the degree of hydraulic connectedness/hydraulic separation between the Berea sandstone (the upper aquifer) and overlying zones of significant saturation conducted by EPA and BAH (Enclosures C and D, respectively).

To summarize the findings of EPA and its contractors, in the evaluation of bedrock competency, Akana's analysis shows that the OSDC should be able to be constructed on the existing bedrock with the proposed fill capacity without compromising a typical composite liner system, if the fill sequencing and other conditions, as discussed in Enclosure A, are carefully considered and rigorously followed during operation of the landfill.

For the review of the nature of discontinuity defined in boring logs, EPA and BAH both observed mechanical breaks and natural formation fractures in the boring logs and photographs, but agreed that it is not possible to differentiate between mechanical and natural fractures with

absolute certainty based on the photograph logs. However, both reviews note observations of reduced fracture density and silt/sand lens density with depth, suggesting the Cuyahoga shale beneath the 680-foot sandstone appears capable of providing a reasonable level of protection for the Berea aquifer from releases from the site.

BAH and EPA also evaluated hydraulic and hydrochemical data for evidence of a hydraulic connection between the Berea and Cuyahoga formations. EPA concluded that there appears to be no evidence that a hydraulic connection exists at the site, but identified limitations in the data that do not make this conclusion definitive. These conclusions and limitations are discussed further in Enclosure C. BAH concluded that available hydraulic and hydrochemical data provide no evidence of hydraulic connection between the Berea and Cuyahoga formations. Based on these data, the Cuyahoga below the 680-foot sandstone provides an effective hydraulic barrier between the Cuyahoga and the Berea.

Sincerely,

Michael D. Harris

Michael D. Harris
Acting Division Director
Land and Chemicals Division

Enclosures

ATTACHMENT A
ON SITE DISPOSAL CELL GEOTECHNICAL FOUNDATION CAPACITY
REVIEW COMMENTS AND RECOMMENDATIONS
AKANA

PORTSMOUTH GASEOUS DIFFUSION PLANT, PIKETON, OHIO
ON SITE DISPOSAL CELL GEOTECHNICAL FOUNDATION CAPACITY
REVIEW COMMENTS AND RECOMMENDATIONS
December 13, 2017

1.0 INTRODUCTION

Akana was contacted as a part of the Booz Allen Hamilton (Booz Allen) team for the demolition and decontamination of the Portsmouth Gaseous Diffusion Plant (PORTS) in Piketon, Ohio, under EPA Contract #EP-W-12-031, Task Order # TO 5535 (Corrective Action Support). After several years of study, including public input following the Comprehensive Environmental Response, Compensation, and Liability Act process, the Department of Energy (DOE) Portsmouth (located in Piketon Ohio), issued a Record of Decision (ROD) to build an On Site Disposal Cell (OSDC) at PORTS in June 2015. Ohio EPA concurred with DOE's ROD.

In response to public feedback concerning the construction of the OSDC, Ohio EPA reached out to the U.S. EPA for independent technical assistance to address concerns about the site earmarked for the OSDC.

This report presents Akana's evaluation of the competency of the soil and foundation at the OSDC location. To meet this objective, Akana's review and analysis focused on the evaluation of the bearing capacity of the underlying bedrock and documentation associated with the borings that referenced fractured and fracturing" in the bedrock with respect to bearing capacity when considering the protection of the underlying groundwater.

Akana reviewed available information and independently estimated the bearing capacity of the underlying bedrock. Akana took into account its experience with landfill liner technologies and configurations with respect to the potential to offer containment and protection of the underlying aquifers.

2.0 TECHNICAL APPROACH

Booz Allen Hamilton provided Akana the following documents:

+ United States Environmental Protection Agency, Region 5—Technical Direction Memorandum, December 4, 2017
+ Appendix B—Boring logs
+ Cross sections A-F
+ EPA RIFS
+ EPA RIFS with Ohio EPA concurrence
+ Figure 1 Cross Sections
+ Section A Rotational Analysis
+ Section A Block Slip Analysis
+ Structural Competency Analysis

The analysis of structural competency of the underlying strata relied on the following information:

+ Geologic Cross-Section II, Drawing No. X-780-C-10620
+ Boring Logs SB-22 through SB-36 (both Terracon and Fluor versions)
+ Well Logs MW-3B to MW-5B (both Terracon and Fluor versions)

The two versions of the logs (Fluor vs Terracon) appeared to represent the same borings but contain different levels of detail. The Terracon logs appear, in general, to represent field logs. The Fluor logs appear to be summary logs. Photographs of the cores were not available for review.

Akana's scope focused on an independent analysis of the structural capacity of the underlying strata; therefore, a specific review of the documents provided has not been prepared. The results and findings are presented in Section 3.0.

Akana understood, from a preliminary review of the documents provided, that there is a difference of opinion regarding the meaning of the description of the underlying shale as fractured and what that term would mean in an analysis of the bearing capacity, as well as the potential of the fractured strata to act as a hydraulic conduit for the flow of contaminated liquids in the landfill.

3.0 REVIEW SUMMARY

In this review and analysis, the bearing capacity of the proposed landfill site was evaluated by developing a stability and subsidence model at the estimated elevation of the base cells of the proposed landfill. Geologic Cross Section II was used to estimate geologic contact and groundwater elevations in relation to the base of the landfill cells. For the first phase of the analysis, a load was placed within the landfill cells adjacent to unloaded cells and modeled to determine the maximum load that could be applied to achieve a factor of safety of 1.5 before subgrade failure occurred. Failure occurs when the rock under the loaded cell causes settlement that results in a displacement or movement in the area that is loaded adjacent to an unloaded portion of the cell that would create a breach in a landfill liner system. Attachment 1, Bearing Capacity Model, depicts the geometry used in the modeling.

The boring logs provided were used to estimate the parameters of the underling geologic elements. Boring log SB-23 is located within the landfill cell footprint and was determined to be representative when compared to the surrounding boring logs. Therefore, the data from SB-23 was used for this analysis. A review of the landfill elevations was used to note that the base elevations ranged from 700 to 720 feet above the datum used. The geologic materials directly below the landfill cells are described as "fractured fresh, sound, dark gray shale" which extends to an elevation of 675 feet. The nature of the fractures in the shale is described as both natural and mechanical. The shale below 675 feet and extending to 615 feet of elevation appears to be slightly more competent. Below 615 feet, the geologic substrate is sandstone, which extends to the bottom of the model used. In all cases, the recorded Rock Quality Designation (RQD) is greater than 90 percent, approaching 100 percent through most of the relevant soil column. High RQD indicates a relatively competent material, even with the indicated fracturing. The water table or piezometric level was set at an elevation of 630 feet.

In its model, Akana used a conservative approach and modeled the upper shale as frictional gravel, due to the lack of strength-testing information. Akana applied an anisotropic strength (multi-directional loading strength of fractured rock) to the gravel of half the Mohr-Columb strength in the horizontal direction, due to the sedimentary nature of the deposit. Akana believes that these assumptions eliminate speculation regarding the strength of the fractured rock strata and views the performance as if it were gravel when analyzing structural performance in all axis directions. A theta value of 30° to 32° was estimated for the shale units (reduced by ½ in the horizontal direction). A very low unconfined compressive strength was conservatively applied to the sandstone.

The analysis indicates the maximum vertical bearing pressure/capacity is 6,000 pounds per square foot (psf), while maintaining a factor of safety of 1.5. This is summarized in Attachment 3, Bearing Capacity Analysis Information Summary. With a bearing capacity of 6,000 psf and using a waste fill density of concrete at 4,050 pounds per cubic yard, the bearing capacity is reached with 40 feet of fill. The modeling

indicates this is the limit to which the landfill could be loaded without causing differential settlement or subsidence between a loaded cell and an unloaded cell that could potentially compromise a liner system.

To address the issue of settlement or subsidence with fill above 40 feet, Akana modeled a proposed landfill loading plan that called for the placement of waste in the adjacent cells simultaneously for the first 40 feet, so that differential settlement between cells is minimized. After the first 40 feet of fill, each cell would be loaded in maximum differential 10-foot increments to the designed fill height. Akana calculated subsidence of the shale based on an estimated elastic modulus of the fractured shale. Akana again assumed, very conservatively, that the fractured shale behaved like gravel, and as a result estimated a modulus of elasticity of about 14,000 pounds per square inch. Akana placed a 1,500 psf load (approximately 10 feet of waste) on top of the previous load, which resulted in about 1,355 psf loading at the base of the cell (due to stress reduction). Similarly, as each 10-foot waste lift is added, the loadings can successively be reduced. Akana calculated subsidence based on linear elasticity. The calculated differential settlement between cells at the base of the cell, based on the above-indicated loading sequence, is less than ½ inch at a fill height of 150 feet. This result should be within the acceptable performance parameters of a composite liner system. Attachment 2, Bearing Capacity Analysis Results, shows the results of Akana's analysis, indicating a maximum differential vertical bearing pressure of 6,000 psf between adjacent cells.

4.0 CONSIDERATIONS

Managing fill sequences for cells and lifts to prevent differential settlement is a common criterion in landfill design and operations and should be included in any operational plan, but was not available in the information Akana reviewed. The modeling indicates that the consideration of fill sequence as a part of the landfill operations will allow the full capacity of the OSDC to be achieved.

In addition, managing groundwater and hydraulic flow pressures above the landfill liner will be critical to maintaining containment. The stability analysis assumes that groundwater does not rise within the foundation materials. The surface of the base of the cell and the liner construction should be carefully monitored, as Akana's calculations assume that the liner and exposed surface of the fractured shale are firm and unyielding prior to waste placement.

Attachment 3, Bearing Capacity Analysis Information Summary, presents the information used in Akana's analysis. The following information on waste densities was considered in evaluation of the OSDC.

+ Concrete[1] = 4,050 pounds per cubic yard
+ Asphalt[2] = 4,050 to 4,140 pounds per cubic yard
+ Rubble[3] = 1,400 pounds per cubic yard
+ Drywall[3] = 500 pounds per cubic yard
+ Scrap Metal[3] (loose light iron sheet metal) = 1,000 pounds per cubic yard
+ Scrap Wood[3] = 300 pounds per cubic yard

Akana's analysis shows that the OSDC should be able to be constructed on the existing bedrock with the proposed fill capacity without compromising a typical composite liner system, if the fill sequencing, as discussed above, is carefully considered and rigorously followed during operation of the landfill.

5.0 REFERENCES

1. Reade Advanced Materials, Providence, RI 401.433.7000. www.reade.com/Particle_Briefings/spec_gra2.html

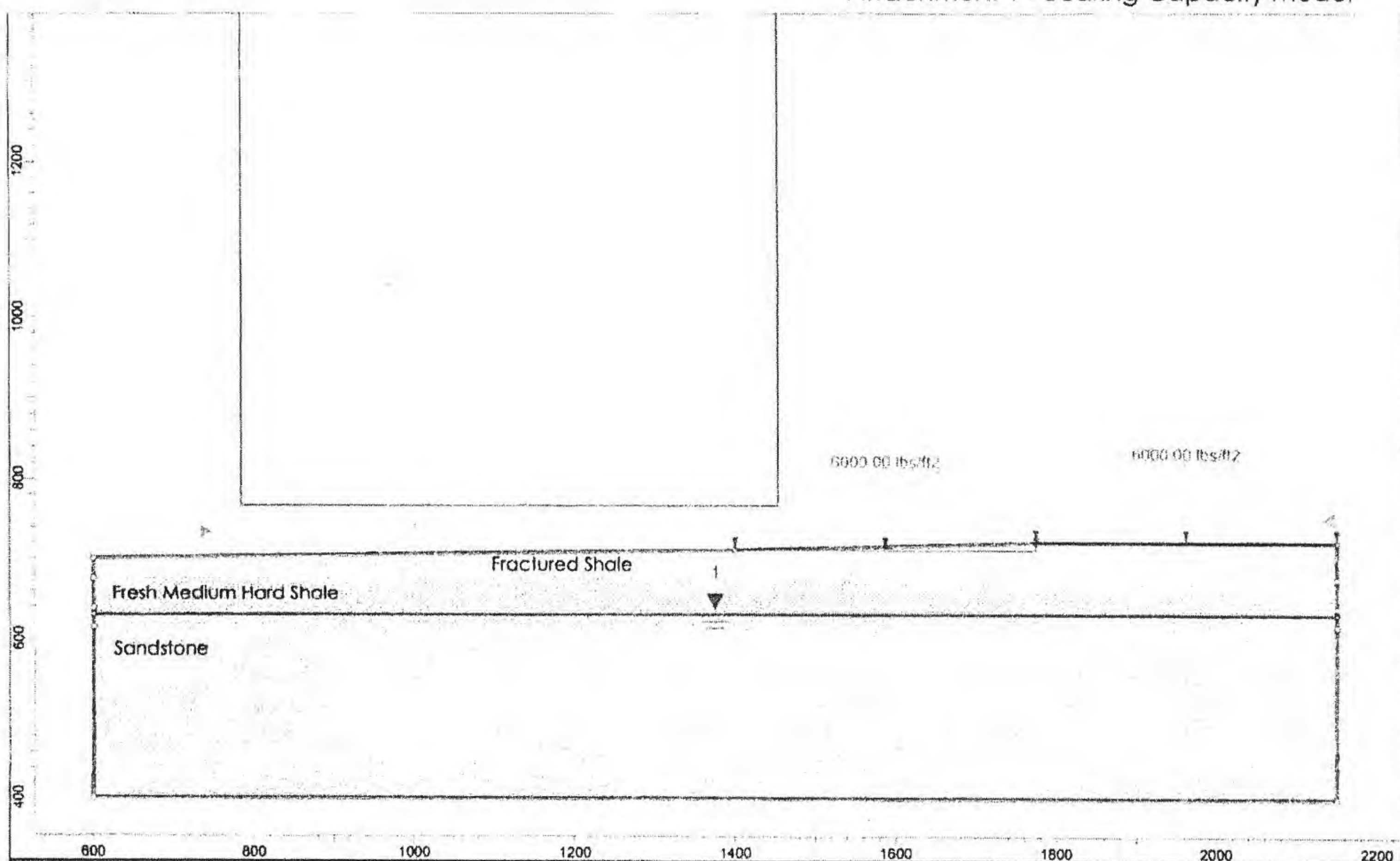
2. Asphalt Pavement Association of Michigan (4,050 lbs/yd3) and LEED EB v. 2.0 Reference Guide (p.256) Table 2 Volume to Weight Conversions (115 lbs per yd2 or 4,140 lbs per yd3).
3. US Green Building Council. "LEED Reference Guide for Green Building Design and Construction 2009 Edition, Section 6- Calculations, Table 2- Solid Waste Conversion Factors. Page 360.

ATTACHMENT 1

BEARING CAPACITY ANALYSIS MODEL

(One Page)

Attachment 1 - Bearing Capacity Model

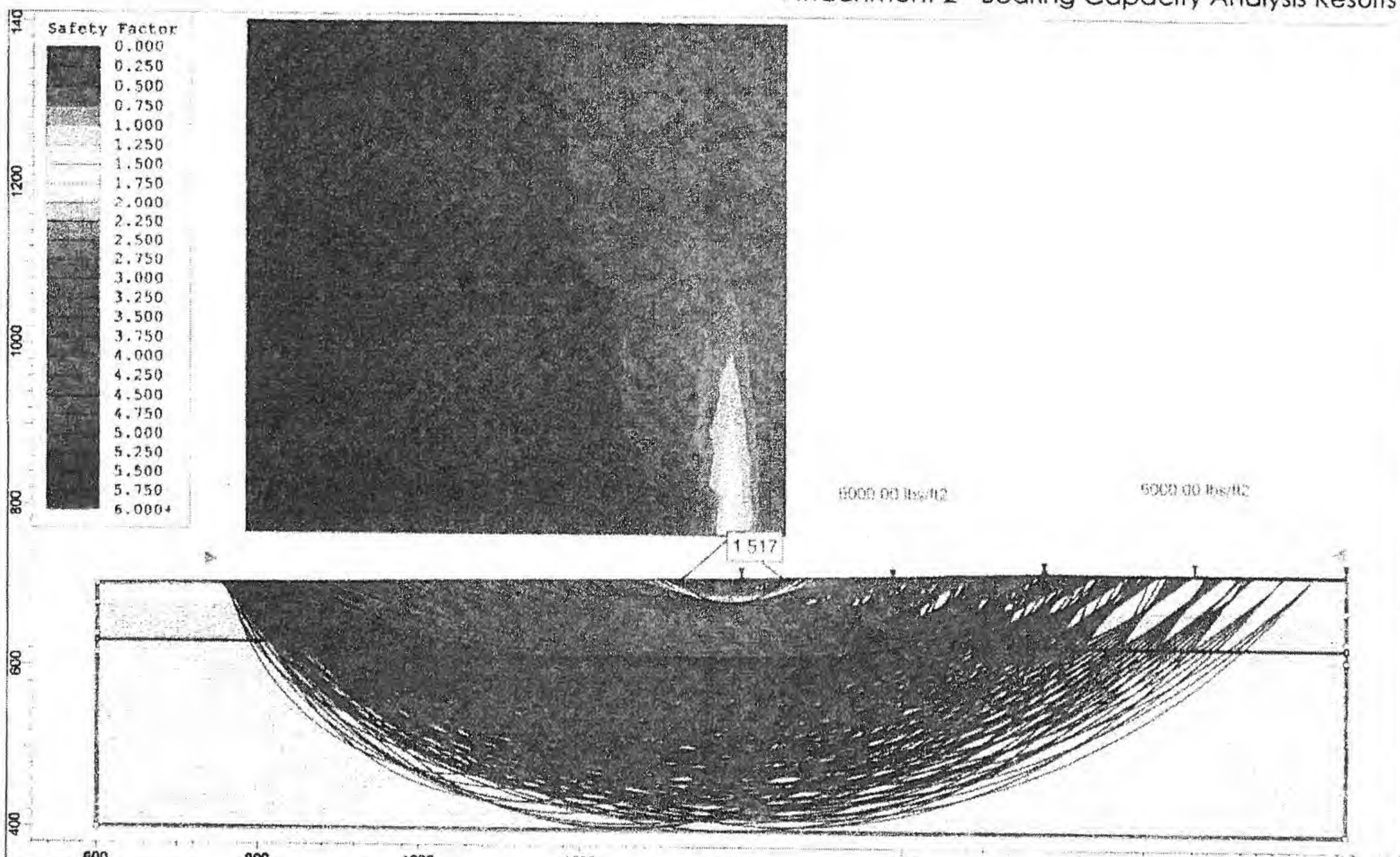


Project	Portsmouths Landfill Bedrock Compency		
Analysis Description	Bearing Capacity		
Drawn By: Rick Thrall, PE GE	Scale: 1:1991	Company: Akana	
Date: 12/9/2017, 12:27:35 PM		File Name: Test.slim	

SLIDE 6.009

ATTACHMENT 2
BEARING CAPACITY ANALYSIS RESULTS
(One Page)

Attachment 2 - Bearing Capacity Analysis Results



Project	Portsmouths Landfill Bedrock Compency		
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Drawn By: Rick Thrall, PE GE	Scale: 1:1991	Company: Akana	
Date: 12/9/2017, 12:27:35 PM		File Name: Test.slim	

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ATTACHMENT 3
BEARING CAPACITY ANALYSIS INFORMATION SUMMARY
(Three Pages)

BEARING CAPACITY ANALYSIS INFORMATION SUMMARY

Slide Analysis Information

Portsmouth's Landfill Bedrock Competency

Program: Roc Science

General Settings

+ Units of Measurement: Imperial Units
+ Time Units: days
+ Permeability Units: feet/second
+ Failure Direction: Right to Left
+ Data Output: Standard
+ Maximum Material Properties: 20
+ Maximum Support Properties: 20

Analysis Options

+ Analysis Methods Used

—Bishop Simplified
—Janbu Simplified

+ Number of slices: 25
+ Tolerance: 0.005
+ Maximum number of iterations: 50
+ Check malpha < 0.2: Yes
+ Initial trial value of FS: 1
+ Steffensen Iteration: Yes

Groundwater Analysis

+ Groundwater Method: Water Surfaces
+ Pore Fluid Unit Weight: 62.4 lbs/ft3
+ Advanced Groundwater Method: None
+ Pseudo-random Seed: 10116
+ Random Number Generation Method: Park and Miller v.3

Surface Options

+ Surface Type: Circular
+ Search Method: Grid Search
+ Radius Increment: 10
+ Composite Surfaces: Disabled
+ Reverse Curvature: Create Tension Crack
+ Minimum Elevation: Not Defined
+ Minimum Depth: Not Defined

Loading

+ 2 Distributed Loads present
+ Distributed Load 1

—Distribution: Constant
—Magnitude [lbs/ft2]: 6000
—Orientation: Normal to boundary

+ Distributed Load 2

—Distribution: Constant
—Magnitude [lbs/ft2]: 6000
—Orientation: Normal to boundary

Material Properties

Property	Fractured Shale	Fresh Medium Hard S	Sandstone
Color			
Strength Type	Anisotropic strength	Anisotropic strength	Anisotropic strength
Unit Weight [lbs/ft3]	120	120	120
Cohesion 1 [psf]	50	50	12000
Cohesion 2 [psf]	50	50	25000
Friction Angle 1 [deg]	30	32	0
Friction Angle 2 [deg]	15	16	0
Angle from 1 [deg]	90	90	90
Water Surface	None	Piezometric Line 1	None
Hu Value		1	
Ru Value	0		0

List of Coordinates

Piezoline: (X – 600, Y – 629.554), (X – 2,150, Y – 629.554)

Line Load: (X – 1,775, Y – 710), (X – 1,400, Y – 710)

Line Load: (X – 2,150, Y – 720), (X – 1,775, Y – 720)

External Boundary

X	Y
600	700
600	675
600	638
600	630
600	615
600	400
2,150	400
2,150	614.277
2,150	615
2,150	630
2,150	638
2,150	675
2,150	720
1,775	720
1,400	710

Material Boundary: (X – 600, Y – 675), (X – 2,150, Y – 675)

Material Boundary: (X – 600, Y – 615), (X – 2,150, Y – 615)

ATTACHMENT B
SEISMIC STABILITY OF THE LANDFILL
US EPA OFFICE OF RESEARCH AND DEVELOPMENT
AND
US EPA REGION 5

US EPA OFFICE OF RESEARCH AND DEVELOPMENT

Documents sent to ETSC showed safety factors greater than 1.0, which appear satisfactory because the OSDC was developed with protectiveness standards; however, the "reasonable protection of the sandstone should be further defined" as this statement is more risk based than engineering based, and would guide any further geophysical methods that might be required.

It is suggested that a graphic of slope stability failure lines/arcs from the analyses conducted be displayed overlain atop the geologic cross sections of concern. If a slope failure or either type (rotational, translational, veneer) is possible through the fractured rock underlying the location of the waste cells, further investigation may be necessary.

US EPA REGION 5

The loading was assumed to be distributed evenly across the footprint of the cell, resulting in static loads that would be concentrated in the center of the distribution. This is a reasonable assumption provided that best management practices are strictly adhered to during landfilling, however a more robust assessment might also include an uneven load distribution, or more eccentric loading across the cell or adjacent cells to model other landfilling scenarios. Another assessment may also include leachate collection above the primary liner in a worst-case-scenario evaluation that assumes any collection systems are not performing as designed or are underperforming.

Page 4 of Akana's evaluation stated that settlement under .5 inches "should be within acceptable performance parameters of a composite landfill liner system." It does not appear that a composite liner system was evaluated as part of this assessment, nor were any material properties such as shear strength in a selected liner system used in assessing liner performance under loading and settlement conditions. This would require an additional assessment regarding the performance of a composite system under the modeled conditions.

ATTACHMENT C
HYDROGEOLOGIC EVALUATION
US EPA REGION 5

- USEPA's evaluation of hydraulic connectivity between the uppermost aquifer and the proposed Onsite Disposal Cell considered the nature and extent of fractures and sandstone layers, data from pump tests, groundwater chemistry, a hydrograph comparison, and a seep investigation.
- Although there is some evidence that a hydraulic connection does not exist at the site, USEPA cannot definitively make this conclusion with the information available and the time allotted for review.

On November 16, 2017, the Ohio Environmental Protection Agency (OEPA) asked the US Environmental Protection Agency (USEPA) for an expedited reasonableness review of geological competency for the proposed location of the Onsite Disposal Cell (OSDC) at the Department of Energy's (DOE) Portsmouth Gaseous Diffusion Plant in Piketon, Ohio (PORTS). Specifically, OEPA asked USEPA to evaluate bedrock competency at the OSDC and the nature of fractures defined in boring logs and whether there is a significant concern for the protection of groundwater under the OSDC.

USEPA reviewed Section 2.2 - Site-Wide Waste Disposition Investigation, Appendices A, B, and C of the RI/FS[1], boring logs and photographs from the Memorandum-to-File[2], and the Hydrogeologic Report for Study Area D[3] to evaluate the nature of fractures in boring logs and whether there is a significant concern for the protection of groundwater under the OSDC. Refer to the Hydrogeologic Report[3] for a complete discussion on the geology underneath the proposed OSDC, including the significant zones of saturation (720 and 680 sandstones) and uppermost aquifer (Berea sandstone).

The evaluation considered multiple lines of evidence from boring logs and photographs showing the nature and extent of fractures and sandstone layers, pump tests investigating for hydraulic interconnectedness and conductivity, groundwater chemistry, a seep investigation, and a hydrograph comparison.

USEPA could not conclusively differentiate from photographs whether a fracture or break was mechanical (i.e. formed during drilling and removal of the rock core; was not present before drilling) or natural (i.e. formed in-situ, existed prior to the investigation, and may be partially mineralized, weathered, or sediment-filled). While the boring logs described natural fractures as being calcite-filled (e.g. SB-24, 135' depth) or clay-coated (e.g. SB-35, 36.65' depth) or exhibiting other kinds of mineralization or sediment coating, the rock cores were not archived after investigation for evaluation, and these features could not be discerned from photographs. Therefore, making deductions on the formation of fracture features with certainty was not possible. However, other observations could be made from the photographs. USEPA observed reduced fracture density in the Cuyahoga shale and Sunbury shale below the 680 sandstone unit, including competent, fracture-free shale immediately below the 680 sandstone. USEPA also observed that rock cores were typically light brown grading to light gray in shallow cores, while deeper cores were a darker gray. Finally, the density of silt or sand lenses reduces with depth in the rock cores, and those lenses are nearly absent in the Sunbury shale. The evidence of reduced fracturing, changes in color, and reduced silt and sand lenses with depth support the hypothesis that the Berea sandstone aquifer is not hydraulically connected to overlying zones of significant saturation and would be protected from contamination in the OSDC. However, other lines of

evidence are needed to prove that a hydraulic connection does not exist between the Berea sandstone and overlying saturated intervals.

A comparison of hydraulic head measurements from monitoring wells and piezometers was completed to determine the vertical head difference between the 680 sandstone and the Berea sandstone (Figures 14 and 20[3]). Hydraulic head measurements from Cuyahoga 680 sandstone piezometers in August 2013 ranged from 676.53'-686.49' above mean sea level (AMSL). Hydraulic head measurements from Berea sandstone monitoring wells in August 2012 ranged from 624.7'-645.6' AMSL. Groundwater flow at the time of measurement in the 680 sandstone moved radially out from the center of Area D, while groundwater flow in the Berea sandstone was to the southeast and southwest. Definitive conclusions should not be made about flow and hydraulic head differences from measurements made at different times. However, the differences in flow direction and hydraulic head suggest that the two water bearing units may move independently from each other, may not be hydraulically connected, and that the Cuyahoga and Sunbury shales are possibly significant confining units. Should the two units be connected, hydraulic head measurements indicate that groundwater flow would move vertically downward from the 680 sandstone, through the Cuyahoga and Sunbury shales, into the Berea sandstone.

Groundwater chemistry was also considered as part of this evaluation. Major ion chemistry of groundwater from the Cuyahoga shale and Berea sandstone was measured from Study Areas A, C, and D (Table 2.7[1]). The magnesium-sulfate rich Cuyahoga shale groundwater shows significant geochemical differences from the sodium-chloride rich Berea sandstone groundwater. Five of the seven monitoring wells screened in the Berea sandstone contain predominantly sodium and potassium cations, and chloride anions. Crucially, all Berea sandstone groundwater samples are lacking sulfate and magnesium. Conversely, Cuyahoga shale groundwater is strongly enriched in sulfate and magnesium. The geochemical signatures of each unit's groundwater suggest that little mixing occurs between the two units. Since the hydraulic gradient between the Cuyahoga and Berea is expected to be vertically downward towards the Berea, the lack of sulfate and magnesium in Berea sandstone groundwater strongly suggests that water within the Cuyahoga shale does not reach the Berea sandstone.

Pump tests were performed in Cuyahoga shale piezometers to, in part, measure the response, or lack thereof, in Berea sandstone monitoring wells. Pump tests were also performed in the Berea sandstone monitoring wells while measuring groundwater response in the Cuyahoga shale. Details of the tests are described in the RI/FS Appendix C[1]. The results of the tests were inconclusive. While hydrographs of piezometer/well pairs during pumping clearly show no response from the monitored unit while pumping occurred in the other unit, only two piezometers were able to sustain yields of greater than 0.1 gpm. An analysis was not completed on the size of the zone of influence for the pumping wells to confirm that the monitored wells were within that zone of influence, and would have been expected to show a response.

The pump tests also measured vertical hydraulic conductivity of the Berea sandstone, Cuyahoga shale, and Sunbury shale within the same borehole[3]. The results indicate that the vertical conductivity of the Cuyahoga shale between the 680 and 720 sandstones ranges from 3.70×10^{-10} to 8.10×10^{-10} cm/s and is between 8.60×10^{-9} and 4.0×10^{-10} cm/s in the Sunbury shale beneath the 720 sandstone. Given that the horizontal conductivity of the 680 sandstone is 1.41×10^{-7} to

1.76×10^{-7} cm/s, it is more likely that groundwater reaching the 680 sandstone will flow horizontally and emerge along a hillside as a seep or spring than flowing vertically and reaching the Berea sandstone.

A seep investigation identified 59 seeps located at variable elevations. The seep investigation concluded that seeps are generally found at the interface above the weathered bedrock surface, but in other instances they were identified as groundwater discharging from sandstone lenses or bedding plane partings in the weathered bedrock[3]. The report goes on to say that "in areas where fractures occur or the bedrock (or weathered bedrock) is sandy and more permeable, some of the groundwater moves downward from the regolith to provide recharge to the deeper bedrock system." Based on this evidence, it is not clear to USEPA that contamination escaping the OSDC will not move horizontally in shale bedding planes or one of the sandstone units and re-emerge in surface water through seeps.

Although there is some evidence that a hydraulic connection does not exist at the site, we cannot definitively make this conclusion. The reliance on photographs of cores rather than the actual cores, the time difference in hydraulic head data, inconclusive and incomplete pump tests, and incomplete analysis regarding the significance of the seeps present at the site limit EPA's ability to make this determination. Other lines of evidence, and more time for the review, are needed to determine whether a hydraulic connection does not exist between the Berea sandstone and overlying saturated intervals.

References

1. U.S. Department of Energy. Remedial Investigation and Feasibility Study Report for the Site-Wide Waste Disposition Evaluation Project at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio. February 2014. https://energy.gov/sites/prod/files/2014/12/f19/Pages%20from%20WD%20RIFS%20D3%20R5%20With%20Ohio%20EPA%20Concurrence%20LetterCAMU%20pgs%201-2400_0.pdf
2. Memorandum-to-File to the DFF&O Waste Disposition Post-Decision - Administrative Record File: Boring Logs and Photos from the Investigation of the Site-Wide Waste Disposition Evaluation Project - Boring Logs/Photos http://portsmoutheic.com/Search.aspx?accession=4-REM-WD-15-20171024.1
3. Hydrogeologic Report for Study Area D (Proposed On-Site Disposal Cell Location) at the Portsmouth Gaseous Diffusion Plant. DOE/PPPO/03-0566&D1. January 2014.

ATTACHMENT D
HYDROGEOLOGIC EVALUATION
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Task 7-02: As directed by EPA, the photo and boring logs provided for borings SB-23, SB-24, SB-30, SB-31, SB-32, SB-35, and SB-36 were compared to determine if the term "mechanical break" used on the drillers logs correlate with the photos of the core. The purpose of this comparison is to determine if it would be more accurate to identify these features as mechanical breaks created during the drilling process or as natural formation factures. The boring logs used for this comparison are identified as either Terracon, Geosyntec, or hand-written logs. The core photos provided include both standard and high-resolution core photos, but only the high resolution photos were used for comparison. Comparisons between boring and photo logs for Berea wells MW-03B, MW-04B, and MW-05B were not possible because photo logs for these locations were not provided.

The comparison of the three boring logs (Terracon, Geosyntec, or hand-written) indicate that these logs are consistent with each other. The Geosyntec logs are less detailed than the Terracon and hand-written logs. As such, the Geosyntec boring logs only characterize the geologic strata and presence and location of natural and "mechanical" fractures in a general sense. However, both the Terracon and hand-written logs identify and characterize the specific fractures observed in the cores. The identification and characterization of fractures in Terracon and hand-written logs were observed to be generally consistent.

The fractures identified as "mechanical" are actual breaks in the core, where the core is separated into two pieces. The nature of the break or fracture can be evaluated, in part, by observing the characteristic and regularity in the core at the break. Those breaks in the core that have been identified as "mechanical" are generally horizontal with virtually no irregularities. It should also be noted that the boring logs identify both "mechanical" and natural fractures in the cores. Although frequently concentrated in specific strata, a considerable number of natural fractures were identified. In general, the remaining fractures appear to be appropriately characterized as "mechanical fractures," although it is not possible to differentiate between mechanical and natural fractures with absolute certainty based on the photo logs. Moreover, some portions of the core photos are not well lit. As a result, it is generally not possible to evaluate the fractures identified on the boring logs in these portions of the core.

Task 7-03: The boring logs identified in Task 7-02, including those boring logs provided for WD-MW-03B, WD-MW-03B, and WD-MW-03B in Appendix B of U.S. Department of Energy (2014), have also been evaluated to determine whether the Cuyahoga and Sunbury Shales left in place above the Berea (uppermost aquifer) will provide a reasonable level of protection for the Berea from releases from the site. The evaluation considers only that portion of the bedrock left in place after excavation and construction of the liner. The liner is projected to be installed at an elevation ranging from 700 ft AMSL on the west side of the proposed landfill to 720 or 725 ft AMSL on the east side of the proposed landfill.

Inspection of the boring and photo logs indicate that integrity of the shallow bedrock remains suspect at the elevation proposed for the landfill liner at a number of boring locations. For example, the boring at WD-SB-30 (on the east side of the proposed landfill where the liner is to be placed at approximately 720 ft AMSL) indicates that weathered shale was identified as low as 714.2 ft AMSL, and sandstone with fractures were found at elevation of between 677.1 and 679.1. In the boring for WD-SB-032 (located roughly in the center of the proposed landfill study

area), fracturing is evident down to an elevation of 700 ft AMSL, well below the projected liner elevation at this location of 720 ft AMSL. At the WD-SB-032 location, competent bedrock was not encountered until 706.9 ft AMSL and with moderate fracturing at 696 ft MSL, which continued downward to the 680 ft sandstone. The borings at WE-SB-036/WD-PZ-09C similarly indicate that fracturing extends beyond the 720 ft AMSL elevation projected for the base of the liner. Due to the weathered and fractured nature of the shallow Cuyahoga at and immediately below the projected depth of the landfill liner, the ability of these strata to meet landfill performance standards requires careful analysis.

Natural fracturing generally appears more prevalent in the Cuyahoga shale above the 680-ft Sandstone. Fractures were also frequently observed in or at the interface with the 680-ft Sandstone. However, with depth below the 680-ft Sandstone, fracturing became much more limited, with only occasional fractures within long reaches of intact shale with thin sandstone lenses. Thus, the Cuyahoga shale beneath the 680 ft sandstone appears capable of providing a reasonable level of protection for the Berea from releases from the site.

Task 7-04: Using the hydraulic data associated with the proposed OSDC site, the hydraulic integrity of the shale units separating the 680-foot sandstone and the Berea sandstone was evaluated. This evaluation was used to determine the level of hydraulic connectedness/hydraulic separation between these units.

As noted above in Task 7-03, the evaluation of the cores of Cuyahoga shale below the 680-ft Sandstone strongly suggests a high degree of hydraulic separation between 680 sandstone and Berea sandstone. The degree of hydraulic isolation can be further evaluated by comparing the elevation of the potentiometric surfaces in both these units. The potentiometric map of the Berea sandstone in Study Area D is provided as Figure D.30 of Appendix D of U.S. Department of Energy (2014). Water level measurements and groundwater flow directions under current conditions within the 680-ft Sandstone are shown in Figure D.27 of Appendix D of U.S. Department of Energy (2014). A comparison of water levels depicted in these figures for these two sandstone units indicates that water levels in the 680-ft Sandstone Unit range from 686 ft AMSL to 683 ft AMSL, while the water levels in the Berea Sandstone range from 645 ft AMSL to 624 ft AMSL. Thus, the water levels in the 680-ft Sandstone are 40 to 60 ft higher in elevation than in the Berea Sandstone. This separation in water levels between the 680-ft Sandstone and Berea Sandstone strongly suggests that the two units are hydraulic isolated.

A program of aquifer testing was conducted at OSDC Area D. The objectives of this aquifer testing included determining the interconnectedness between the Berea Formation and any saturated portions of the stratigraphically higher Cuyahoga Formation. Documentation of this testing program is provided in the OSDC Aquifer Performance Test Technical Memo (Technical Memo) included in Appendix C (Page C-1681) of U.S. Department of Energy (2014).

The degree of hydraulic interconnectedness between the Berea and Cuyahoga Formations was investigated by pumping the Berea Formation and monitoring the response, or absence of response, in the Cuyahoga Formation. Between June 26 and July 3, 2012 communication tests were conducted in each of the following four Berea wells, while water levels were monitored in each Berea well's paired Cuyahoga piezometer:

• Pumped WD-MW03B and Monitored WD-PZ12C.
• Pumped WD-MW04B and Monitored WD-PZ13C.
• Pumped WD-MW05B and Monitored WD-PZ14C.
• Pumped WD-MW06B and Monitored WD-PZ11C.

Each test was started by pumping the Berea well at 0.1 gallons per minute (gpm). If the Berea well yield was sufficient (i.e., > 0.1 gpm), the test progressed by selecting additional pumping rates of increasing magnitude. If the Berea well yield was insufficient (i.e., <0.1 gpm), the Berea well was pumped dry and recharge was recorded. No Berea wells were capable of producing a yield of 0.1 gpm or greater. As a result, the tests were relatively short in duration. Nevertheless, a significant change in the water level in the Berea was induced at each pumping location. The hydrographs for these four tests are provided in Figures 2-3, 2-4, 2-5, and 2-6 of the Technical Memo. As these hydrographs indicates, these short-term pump tests produced no noticeable impact in the overlying 680-Sandstone unit at each well pair.

Constant rate yield tests (CRT) were also conducted in the open boreholes in the Cuyahoga Formation. During the yield tests in WD-PZ11C, WD-PZ13C, and WD-PZ14C, nearby Berea wells were monitored to detect any evidence of hydraulic communication between the Cuyahoga and Berea Formations. Further supporting the lack of hydraulic connection between the 680-ft Sandstone and Berea Sandstone, Berea well hydrographs collected during the Cuyahoga CRTs record no reaction to pumping in the Cuyahoga Formation (Figures 3-6 to 3-9 and 3-15 to 3-18 in Tech Memo).

A multi-well aquifer test was also conducted in the Cuyahoga. Analysis of resulting data indicated a range of storativity in the Cuyahoga from 3 X 10-4 to 5 X 10-4. These values of storativity are representative of a confined aquifer, indicating that the 680-ft Sandstone layer in the Cuyahoga is hydraulically isolated, both from above and below.

In addition to aquifer testing, eight bedrock cores were collected in Study Area D for permeability testing (U.S. Department of Energy, 2014a). Saturated vertical hydraulic conductivity was measured in all samples by using the flexible wall method. The vertical hydraulic conductivity of the 680-ft sandstone zone at Study Area D was determined in laboratory testing to be 0.0005 ft/day to 0.004 ft/day. The laboratory testing also indicated that the shale in the Cuyahoga Formation had vertical hydraulic conductivities much lower than those in the sandstone (ranging from 0.000001 ft/day to 0.0009 ft/day). The low vertical hydraulic conductivity measured in the Cuyahoga Shale provides a further indication of the hydraulic isolation provided by the Cuyahoga, particularly in unfractured portions of the formation.

Groundwater chemistry in both the saturated zones of the Cuyahoga and the Berea formations has also been investigated (U.S. Department of Energy, 2014a). The groundwater chemistry in the two formations have been shown to be different. The Berea has a sodium chloride-type hydrochemical facies while the Cuyahoga has a magnesium sulfate-type hydrochemical facies. These differences in hydrochemical characteristics further indicate that the groundwater in the Berea is isolated from the Cuyahoga.

As discussed above, available hydraulic and hydrochemical data provide no evidence of hydraulic connection between the Berea and Cuyahoga formations. Based on these data, the Cuyahoga below the 680-ft Sandstone provides an effective hydraulic barrier between the Cuyahoga and the Berea. This is consistent with the boring logs for the deeper Cuyahoga which show only limited fracturing in this portion of the Cuyahoga.

References

U.S. Department of Energy, 2014a. *Hydrogeologic Report for Study Area D (Proposed On-Site Disposal Cell Location) at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*; January 2014.

U.S. Department of Energy, 2014b. *Remedial Investigation and Feasibility Study Report for the Site-Wide Waste Disposition Evaluation Project at the Portsmouth Gaseous Diffusion Plant, Piketon, Ohio*; February 2014.